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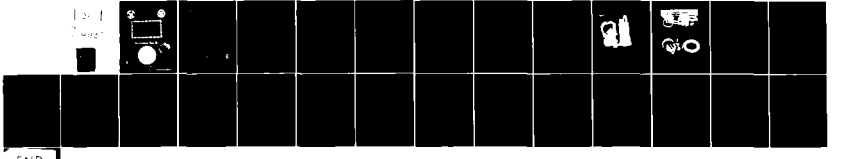

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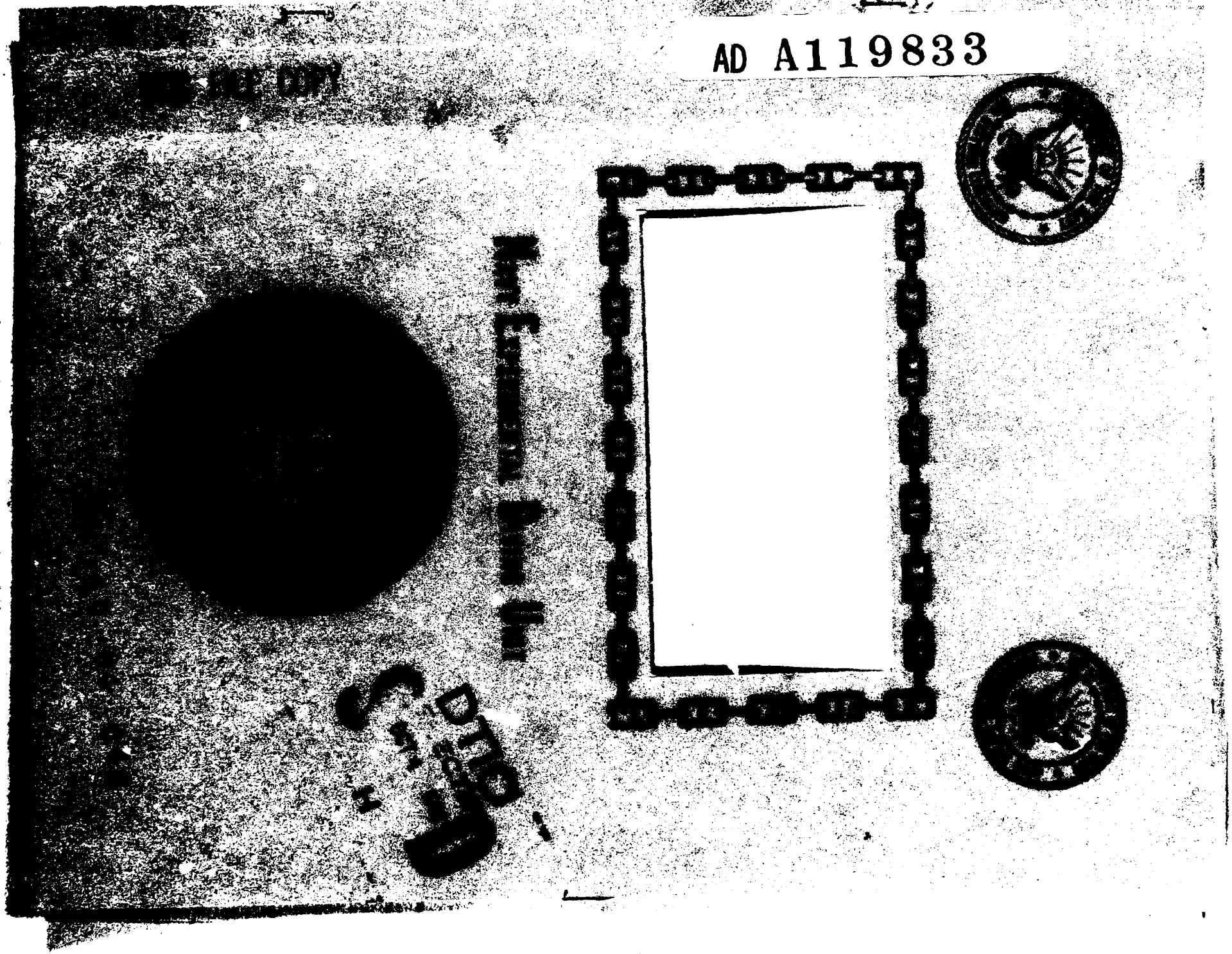

DEPARTMENT OF THE NAVY
NAVY EXPERIMENTAL DIVING UNIT
PANAMA CITY, FLORIDA 32407

NAVY EXPERIMENTAL DIVING UNIT

REPORT NO. 1-82

EVALUATION OF THE EFCOM SC-100M/120M/125M WIRELESS UNDERWATER COMMUNICATOR

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APRIL 1982

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In June 1981, the EFCOM SC-100M/120M/125M wireless communications system was evaluated in conjunction with the AGA DIVATOR 324 Full-Face Mask by the Navy Experimental Diving Unit. The purpose was to determine the systems suitability for U.S. Navy use with open-circuit Self-Contained Underwater Breathing Apparatus (SCUBA). The EFCOM system was evaluated for intelligibility, reliability and human engineering.

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The EFCOM Wireless Communicator System is considered to be a reliable and effective means of communication for the U.S. Navy SCUBA diver.

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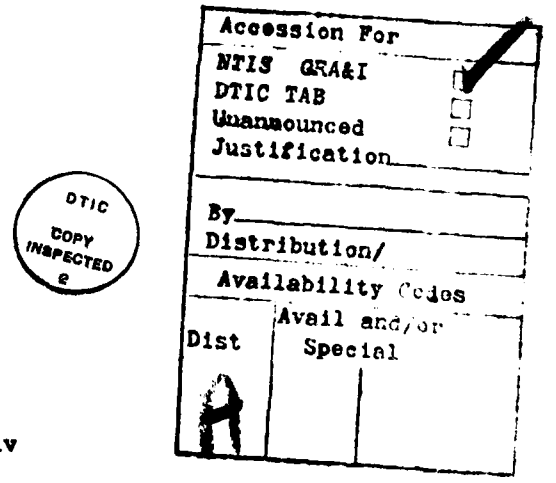

Glossary

AMPS	Amperes
cm	Centimeters
db	Decibels(s)
°C	Degrees Centigrade
FSW	Feet-of-Seawater
FFM	Full-Face Mask
ft	Foot (feet)
in	inch(es)
Kg	Kilogram(s)
kHz	Kilohertz
LED	Light Emitting Diode
m	Meters(s)
ma	Milliampere
Mil Spec	Military Specification, MIL-STD-1472B
MRT	Modified Rhyme Test
NEDU	Navy Experimental Diving Unit
%	Percent
lbs	Pounds
RMS	Root Mean Square
SCUBA	Self-contained Underwater Breathing Apparatus
SD	Standard Deviation
V	Volt(s)
VOX	Voice Activated Microphone
W	Watts(s)
yds	Yards

Abstract

In June 1981, the EFCOM SC-100M/120M/125M wireless communications system was evaluated in conjunction with the AGA DIVATOR 324 Full-Face Mask by the Navy Experimental Diving Unit. The purpose was to determine the systems suitability for U.S. Navy use with open-circuit Self-Contained Underwater Breathing Apparatus (SCUBA). The EFCOM system was evaluated for intelligibility, reliability and human engineering.

The EFCOM system produced an overall intelligibility of 79.3% during manned open-water testing using the Modified Rhyme Test as the evaluation criteria with effective range of at least 300 yds. Human engineering aspects of the EFCOM system were found to be more than adequate with no material failures encountered during testing.

The EFCOM Wireless Communicator System is considered to be a reliable and effective means of communication for the U.S. Navy SCUBA diver.

I. INTRODUCTION

In June 1981, NEDU conducted a manned open-water evaluation of the EFCOM SC-100M (diver unit) and SC-120M/125M (surface unit) wireless underwater communicator. Testing was accomplished in accordance with NAVSEA Task Number 81-8 to determine the system's suitability for U.S. Navy use with open-circuit SCUBA. The SC-100M/120M/125M was evaluated for intelligibility, reliability and human engineering.

This system is manufactured by EFCOM Communication Systems, 18851 Barden Avenue, Divine, California 92715 (phone number: 714-752-2891). The AGA FFM, which was tested as an integral part of the communicator, is manufactured by AGA SPIRO AB, S-181 81 Lidingo, Sweden, and distributed exclusively by EFCOM in the United States.

II. EQUIPMENT DESCRIPTION

The EFCOM SC-100M/120M/125M is a wireless acoustic communication system which operates on an amplitude modulated frequency of 31.5 kHz. It can provide diver-to-diver, diver-to-surface and surface-to-diver communications.

The diver-carried unit (SC-100M) (FIGURE 1) contains a transmitter, receiver and nickel-cadmium battery pack. Internal VOX system, squelch and gain control circuitry provide automatic operation thus leaving the divers hands free to perform his task.

The SC-100M is used in conjunction with an SPM-1 AGA FFM (FIGURE 1). This is a stock AGA Divator 324 second stage with the EFCOM noise cancelling mike and bone conductor earphone installed in the FFM. The AGA DIVATOR 324 FFM was evaluated for inclusion on NAVSEA Instruction 9597.1 (List of Equipment Authorized for Navy Use) in March 1980 and meets all requirements for use with open-circuit SCUBA and any authorized first stage SCUBA regulator.

The SC-125M (FIGURE 2) is the surface unit used for communication between divers and topside. The surface units require integration with an SC-100M which is placed in a cavity provided in the SC-125M housing. The SC-125M utilizes the SC-100M's transmitting, receiving, squelch and automatic gain control functions. The surface unit itself provides a loudspeaker, hand-held noise cancelling microphone, capability of external power supply or internally rechargable batteries, recorder jack, and provision for a headset with boom mike. A transducer is lowered into the water to receive and transmit communications with the divers.

The SC-100M may be converted to a surface unit independent of the SC-125M by use of the SC-120M (FIGURE 3) Surface Accessory Kit. This is a less expensive unit which uses the SC-100M to communicate with divers via a headset with boom mike. The loudspeaker, recorder output and other featurs of the SC-125M are not available in this mode. However, communication and intelligibility are the same in each model of surface units as the electronic circuitry is common to both.

Figure 1. EFCOM SC-100M and SPM-1 AGA FFM.

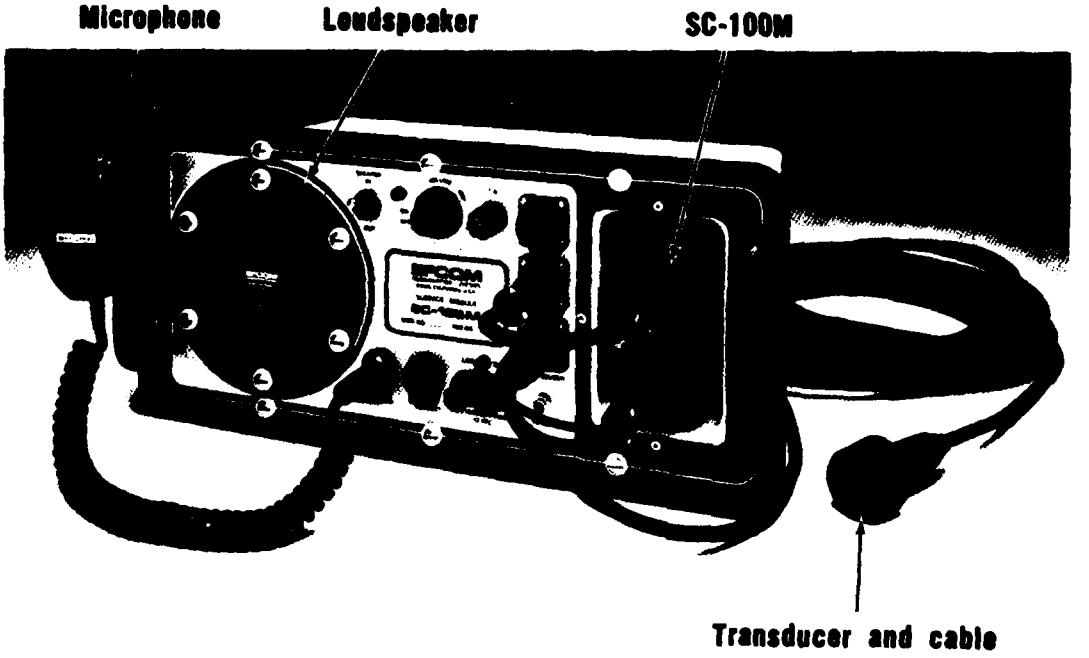

Figure 2. SC-125M Surface Module.

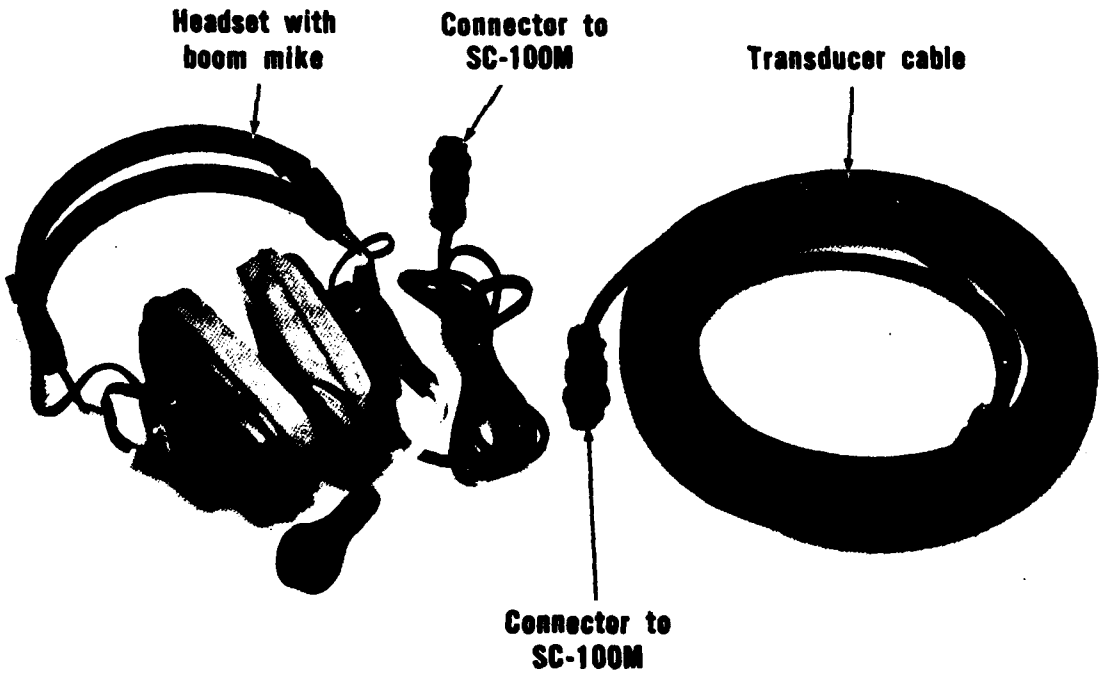

Figure 3. SC-120M Surface Accessory Kit,(used in conjunction with SC-100M).

A complete set of manufacturer specifications on the EFCOM SC-100M, SC-125M, SC-120M and SPM-1 AGA FFM is included in TABLE 1.

III. TEST PROCEDURE

A. Intelligibility Tests

(1) Intelligibility tests were conducted utilizing one in-water diver pair equipped with SC-100M's and SPM-1 AGA FFM's and one topside dive supervisor using the SC-125M or SC-120M.

(2) Topside and in-water test subjects used the standard NEDU MRT word lists. These word lists provides a reading list for one subject and a response sheet for the other test subjects. Six diver-subjects were used during the evaluation with all subjects rotating through topside diver-reader and diver-listener positions. APPENDIXES A1 and A2 provides an example of the MRT.

(3) A minimum of four dive sets were made at each depth to evaluate intelligibility. Diver-to-diver, diver-to-topside and topside-to-diver communication modes were evaluated.

(4) Tests were conducted in 30, 60 and 100 FSW with divers normally 100 feet apart facing each other. The first test series was conducted in 30 FSW and the last in 100 FSW.

(5) To determine the percent correct for these tests, the following formula was utilized (Vancott and Kincaid, 1972):

$$\% \text{ correct} = 2 \times \left(\text{number right} - \frac{\text{Number wrong}}{4}\right)$$

B. Range Tests. The same test procedure as the intelligibility test was utilized except that only one dive-pair/topside supervisor was used and all tests were conducted at 60 FSW. The maximum range tested was 300 yds apart in all three test modes (diver-to diver, diver-to-topside and topside-to-diver).

C. Human Engineering Evaluation. Following each test dive, each dive pair and topside supervisor filled out a questionnaire evaluating pre-dive, in-water and post-dive human engineering aspects of the communicators. APPENDIX B provides a copy of the evaluation form used.

IV. RESULTS AND DISCUSSION

A. Intelligibility Tests:

Because intelligibility is the ultimate index of the effectiveness of any voice communication system, an objective means of assessing the intelligibility of the EFCOM system was required. The Griffiths (1967) version of the previously developed MRT (House, et al, 1965) was employed for this purpose. It was chosen because of its ease of administration and

TABLE 1

MANUFACTURER EQUIPMENT SPECIFICATIONS

A. SC-100M Wireless Underwater Communicator (Diver-Worn Unit).

Range	Approximately 500m (548 yds) under optimum conditions
Depth Rating	65m (213 ft)
Automatic Gain Control (AGC)	Range 100dB
Carrier Frequency	31.5 kHz amplitude modulated
Voice Operated Transmitter (VOX)	Automatic - Factory adjusted
Squelch	Internal squelch circuitry
Activation	Water-activated switch
Transducer	Piezo-electric type
Transducer Acoustic Power Output	Approximately 0.5 W
Battery Condition Indicator	LED type
Charge Indicator	LED type
Power Requirements	Ten 1.25V rechargeable nickel-cadmium batteries (factory-supplied) or eight 1.5V Alkaline penlight batteries
Charger	12V - 50mA for 110V Power Supply
Battery Life	Six to seven hours actual use with nickel-cadmium batteries
Storage Temperature	-54° to +71°C
Operating Temperature	-2° to +45°C
Operating Medium	Salt, fresh or polluted water
Weight (in air)	1.6kg (3.52 lbs)
Weight (in water)	0.7kg (1.55 lbs)
Housing Dimensions	Height: 20.32 cm (8.00 in) Depth: 4.83 cm (1.90 in) Width: 9.65 cm (3.80 in)

TABLE 1

MANUFACTURER EQUIPMENT SPECIFICATIONS (continued)

B. SPM-1 AGA Full-Face Mask.

The mask is constructed of materials resistant to impact, corrosion, temperature extremes and ultraviolet radiation.

The mask can easily be donned and doffed due to its light weight and the use of adjustable quick-release buckles on the spider harness.

Eye glasses (wire rimmed) may be affixed to the mounting tabs provided.

A DIVATOR 324 fully balanced second-stage regulator which is included on NAVSEAINST 9597.1 Change 4 (Equipment Authorized for Navy Use) is built into the mask.

A slight positive pressure presses the sealing skirt against the face - assisting in a comfortable seal against most facial contours.

Automatic defogging is achieved by directing the incoming air/gas via the defogger ports across the visor.

Uses a small oral-nasal cavity and separate inhalation and exhalation channels.

Communications incorporated into the mask by mounting a microphone into the oral-nasal cavity via the removable cover plate.

Replaceable, wide-view visor is made of high-impact resistant material.

C. SC-120M Surface Accessory Kit.

Head Set	600 Ohm
Boom Microphone	300 Ohm Dynamic Noise Cancelling
Transducer Cable Length	10.00m (32.7 ft) Sections (up to 3 sections may be used in series)

TABLE 1

MANUFACTURER EQUIPMENT SPECIFICATIONS (continued)

D. SC-125M Surface Module.

Audio Output	6 W RMS
Microphone	Hand-held noise-cancelling microphone
Power Supply	12V-6 Amps internal chargeable maintenance free battery or 12V external power supply
Battery Life	9 hrs continuous use at 6 W RMS
Battery Condition Indicator	LED Type
Auxiliary Outputs	Record Jack, Headset/Boom Mike, Remote Speaker
Transducer Cable Length	10 m (32.7 ft)
Operating Temperature	-20° to +45°C
Storage Temperature	-54° to +71°C
Weight	11 kg (24 lbs)
Housing Dimensions	Height: 19.1 cm (7.5 in) Depth: 25.4 cm (10.0 in) Width: 40.6 cm (16.0 in)

scoring, its stability with respect to learning effects, and because it requires minimal listener training. Gelfand, et al, 1978, report the successful use of the test on a 1600 FSW dive. Although the MRT is not phonetically balanced to represent everyday speech, it is efficient and useful because it requires perception of consonantal sounds (sounds that are difficult to transmit successfully) and are thus more important than vowels to intelligibility.

The MRT consists of 50 sets of words, with five words in each set (see APPENDIX A1 and A2). In a typical test, a reader reads one specific word from each set in the following way: "Number 1, the word is ___, Number 2, the word is ___," etc. He was instructed to pause several seconds between each phrase. The listener who held a response sheet with the same 50 sets of words, marked the correct word read from each set by the reader. Eight different reading lists were randomly employed during the course of the evaluation and six different response lists. The order of the words within each set on the various response word lists were different to counterbalance the tendency of listeners to mark the first word in a set when in doubt or when guessing. Once a word list was completed, the percent correct was calculated using the following formula (Van Cott & Kincaid, 1972):

$$\% \text{ correct} = 2 \times \left(\text{number right} - \frac{\text{Number wrong}}{4}\right)$$

The number of wrong answers was divided by four and subtracted from the number of right answers. The resultant was then multiplied by two. This manipulation was essentially a correction factor for guessing.

The intelligibility criteria for military voice communications systems is set forth in MIL-STD-1472B (see references). This military standard sets the minimum acceptable intelligibility when using the MRT as the evaluation criteria as 75% correct.

TABLES 2 through 4 present mean intelligibility score for diver-to-diver, diver-to-topside and topside-to-diver, respectively. A minimum of 4 tests were conducted in each operational mode. Scores ranged from a low mean score of 69% correct to a high mean of 86% correct. The overall average, based on a total of 55 tests in all three modes, was 79.1% (excluding range tests). However, the data tabulated in TABLES 2 through 4 is in chronological order for each mode. A thorough analysis will reveal that in every mode at each depth, the percent correct increased as the number of dives progressed.

Testing took place using six different diver-subjects over a two-week period. Any VOX operated communicators of this type have a definite learning curve associated with effective use of the equipment. Near the end of the evaluation the test subjects were much more proficient with the EFCOM. Use of a "throw-away" word to activate the VOX (such as the word "ah") became instinctive. Also, the diver-subjects' awareness of the need not to pause in the middle of a sentence, since this allowed the transmitter to shut off if the pause lasted more than one second, was much increased and intelligibility scores improved accordingly. In fact, if only the last half of each set of

TABLE 2

DIVER-TO-DIVER INTELLIGIBILITY SCORES

A. DEPTH: 30 FSW

Dive No.	Score (% Correct)
1	60.4
2	65.2
3	70.0
4	80.5
Mean Score:	69.0 (SD = 8.6)

B. DEPTH: 60 FSW

Dive No.	Score (% Correct)
1	60.4
2	80.0
3	84.0
4	84.8
Mean Score:	77.3 (SD = 11.5)

C. DEPTH: 100 FSW

Dive No.	Score (% Correct)
1	75.0
2	60.4
3	84.4
4	75.0
Mean Score:	73.7 (SD = 9.9)

D. Overall Diver-to-Diver Intelligibility Score: 73.3%.

NOTE: Dives are listed in chronological order with the first test series done at 30 FSW and the last at 100 FSW.

TABLE 3

DIVER-TO-TOPSIDE INTELLIGIBILITY SCORES

A. DEPTH: 30 FSW

Dive No.	Score (% Correct)
1	77.2
2	91.6
3	84.6
4	86.4
Mean Score:	84.9 (SD = 5.9)

B. DEPTH: 60 FSW

Dive No.	Score (% Correct)
1	74.8
2	84.0
3	77.2
4	86.8
5	79.6
6	87.6
7	91.6
8	94.0
Mean Score:	84.4 (SD = 6.8)

C. DEPTH: 100 FSW

Dive No.	Score (% Correct)
1	75.0
2	74.8
3	74.8
4	86.0
5	84.4
Mean Score:	79.0 (SD = 5.7)

D. Overall Diver-to-Topside Intelligibility Score: 82.8%.

NOTE: Dives are listed in chronological order with the first test series done at 30 FSW and the last at 100 FSW.

TABLE 4

TOPSIDE-TO-DIVER INTELLIGIBILITY SCORES

A. DEPTH: 30 FSW

Dive No.	Score (% Correct)
1	84.4
2	84.4
3	87.6
4	87.6
Mean Score:	86.0 (SD = 1.8)

B. DEPTH: 60 FSW

Dive No.	Score (% Correct)
1	67.8
2	70.0
3	91.6
4	60.4
5	65.2
6	67.6
7	77.2
8	84.4
9	80.6
10	89.2
11	80.4
12	96.4
13	79.6
14	94.0
Mean Score:	78.9 (SD = 11.4)

C. DEPTH: 100 FSW

Dive No.	Score (% Correct)
1	79.6
2	67.6
3	70.0
4	77.2
5	84.4
Mean Score:	75.8 (SD = 6.9)

D. Overall Topside-to-Diver Intelligibility Score: 80.2%

NOTE: Dives are listed in chronological order with the first test series done at 30 FSW and the last at 100 FSW.

data is considered in each mode tested, the overall percent correct (excluding range tests) increases from 79.1 to 83.5%. This is important to note since it proves that the low initial scores recorded at 30 FSW (see TABLES 2 through 4) were due to lack of familiarization with the equipment rather than actual EFCOM design limitations.

It is also significant that the tests done in 100 FSW did not show any substantial degredation in intelligibility when compared to the 30 and 60 FSW tests. In many communicators where intelligibility is marginal, increased air density reduces performance which was not the case with the EFCOM system.

As with any acoustic communicator, care had to be taken to insure that physical barriers did not exist between diver-subjects so that the transmitted signals were reflected back prior to reaching their target. In addition, all tests were conducted with the diver-subjects facing each other since the divers body would significantly reduce the transmitted signal if placed between the transducer mounted on his weight belt and the target. It was also observed that the SC-100M did not function well if placed underneath a buoyancy compensator. The air in the compensator would reflect and distort the acoustic signal from the SC-100M's transducer and reduce the communicator's effectiveness. Finally, when topside-to-diver communication was taking place, it was important that the transducer suspended from the surface unit be placed below any thermoclines between the diver-subjects and the surface. Thermoclines will reflect or attenuate the transmitted acoustic signal thus making it necessary to suspend the topside transducer in the same temperature zone as that in which the divers are working. All of these limitations in the equipments performance are inherent in any acoustic communicator system and were not a function of the EFCOM design.

B. Range Tests:

The EFCOM SC-100M/120M/125M has an advertised range of 500m (548 yds). Testing at NEDU was performed with divers normally 100 feet (30.3m) apart. However, late in the test scenario, a range test was conducted in 60 FSW. Divers were placed 27.2m (300 yds) apart facing each other and intelligibility was evaluated in each mode of operation. TABLE 5 lists the results of these tests. At the time of the NEDU evaluation, manufacturers range specifications had not been established. Consequently, the EFCOM was tested to the maximum range that was considered to be appropriate for normal Navy diving operations. A mean score of 82% correct was recorded on the MRT.

C. Human Engineering:

APPENDIX B illustrates the form used to evaluate human engineering parameters for the EFCOM. In all categories, the SC-100M/125M was found to be comfortable, easy to don and doff with few problems experienced by the diver-subjects in the water. Evaluation forms revealed that most diver-subjects preferred to wear the EFCOM SC-100M on a separate belt similar to a weight belt. This facilitated doffing the system in the water.

TABLE 5

INTELLIGIBILITY SCORE AT 222 m (300 yds)

DEPTH: 60 FSW

	Score (% Correct)
Diver-to-Diver:	81.2
Diver-to-Topside:	87.6
Topside-to-Diver:	77.2
Mean Score:	82.0 (SD = 5.2)

A unique feature of the SC-100M is that, while it turns on automatically upon entry into the water, the unit shuts off if any connector between the SC-100M and the SPM-1 AGA FFM is broken. This allows the SC-100M to be disconnected from the AGA FFM in the water without electrolytic corrosion occurring at the connector pins. This factor greatly facilitates ditching the unit at the surface prior to re-entering a small craft.

The SC-125M topside unit was functional and water resistant. The combination of loudspeaker and head set/boom-mike provided excellent communication between the diver-subjects and topside supervisor while allowing other topside parties to monitor the conversation via the loudspeaker. The SC-120M surface accessory kit provided a mobile topside unit for the dive supervisor whenever the loudspeaker was not required and provided communications quality identical to the SC-125M.

All transducers, cables and connectors were quite robust and able to take a reasonable amount of abuse. No material, mechanical or electrical failures were experienced during the 75 man-hours of use logged during the evaluation.

The AGA DIVETOR 324 FFM was well received by all test subjects. It is easy to use and provides one of the most comfortable full-face seals available on the market today.

D. General:

While MRT evaluations produced an overall mean of 79.3% scores correct, evaluation forms revealed the ability of the test subjects to completely communicate normal sentences and phrases with other test subjects at a level approaching normal topside speech.

The EFCOM was tested to a maximum depth of 100 FSW. Manufacturer specifications set a maximum depth limit of 213 FSW. Since all seals in the EFCOM SC-100M are O-ring type, no problems are expected in using this unit to the maximum depths for open-circuit SCUBA established in the U.S. Navy Diving Manual.

V. CONCLUSIONS

Intelligibility scores obtained with the EFCOM were well within military standard limits. Subjective evaluations by test subjects indicate an overall favorable reaction to the equipment.

The range of the EFCOM is considered to be satisfactory to meet forseeable U.S. Navy requirements and no significant human engineering problems, material or reliability deficiencies were encountered during the evaluation.

The EFCOM SC-100M/120M/125M wireless underwater communicator with AGA DIVETOR 324 FFM is considered to be a reliable and effective means of communication for the Navy SCUBA diver. While a learning curve does exist when using this type of equipment, the EFCOM is well engineered and sufficiently automated so that on-the-job training is easily and quickly accomplished.

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APPENDIX A1

MRT READING WORD LIST SAMPLE

	A	B	C	D	E		A	B	C	D	E
1.	bat	batch	bash	bass	**badge**	26.	led	shed	red	wed	**fed**
2.	laws	long	log	**lodge**	lob	27.	**sold**	cold	hold	told	gold
3.	**wig**	with	wit	witch	wick	28.	dig	**wig**	big	rig	pig
4.	**dumb**	dub	doth	duff	dove	29.	**kick**	chick	thick	pick	sick
5.	cuff	**cub**	cut	cup	cud	30.	**fin**	tin	shin	kin	thin
6.	**dig**	din	dic	dim	dill	31.	bark	**dark**	mark	lark	park
7.	dun	dud	dung	**dub**	dug	32.	gale	pale	**tale**	bale	male
8.	**fill**	fig	fin	fizz	fib	33.	peel	feel	eel	**heel**	keel
9.	**leave**	liege	leach	leash	lead	34.	will	hill	**kill**	till	bill
10.	**toss**	taj	tong	talks	tog	35.	feel	reel	seal	**zeal**	veal
11.	lash	lack	lass	laugh	**lath**	36.	shame	**game**	came	same	tame
12.	mat	**mad**	math	man	mass	37.	ten	pen	den	**hen**	then
13.	beige	base	**bayed**	bathe	bays	38.	pin	sin	tin	**win**	fin
14.	pass	**path**	pack	pad	pat	39.	**thin**	tin	chin	shin	gin
15.	peak	peas	**peal**	peace	peat	40.	**thee**	dee	lee	knee	zee
16.	pick	**pit**	pip	pig	pitch	41.	rent	**bent**	went	dent	tent
17.	pup	puff	pub	**puck**	pus	42.	hip	**rip**	tip	dip	lip
18.	hath	hash	half	have	**has**	43.	top	**hop**	pop	cop	shop
19.	we're	weal	**weave**	weed	wean	44.	yore	**gore**	wore	lore	roar
20.	sad	sat	sag	sack	**sap**	45.	vie	thy	fie	**thigh**	high
21.	sheen	sheave	sheathe	sheath	**sheaf**	46.	zip	lip	nip	gyp	**slip**
22.	**sing**	sip	sin	sit	sick	47.	nest	best	vest	**rest**	west
23.	sud	**sum**	sub	sun	sung	48.	bust	just	rust	gust	**dust**
24.	tab	tan	tam	**tang**	tap	49.	mat	vat	**that**	fat	rat
25.	**teethe**	tear	tease	teel	teeth	50.	way	may	**gay**	they	nay

APPENDIX A2

MRT RESPONSE WORD LIST SAMPLE

NAME:_____ RIG OR LOCATION:_____ DATE:_____

	A	B	C	D	E		A	B	C	D	E
1.	batch	bash	bass	bat	badge	26.	wed	shed	led	red	fed
2.	long	laws	lob	lodge	log	27.	told	hold	gold	cold	sold
3.	wig	with	witch	wit	wick	28.	dig	wig	rig	pig	big
4.	dumb	dub	duff	dove	doth	29.	thick	chick	kick	sick	pick
5.	cud	cup	cuff	cut	cub	30.	fin	tin	kin	thin	shin
6.	din	dim	dill	dig	did	31.	lark	dark	park	mark	bark
7.	dug	dun	dung	dub	dud	32.	pale	gale	tale	male	bale
8.	fin	fig	fib	fizz	fill	33.	heel	keel	feel	peel	eel
9.	leash	lead	leave	leach	liege	34.	till	hill	bill	kill	will
10.	taj	tog	tong	toss	talks	35.	veal	reel	zeal	feel	seal
11.	lass	laugh	lash	lath	lack	36.	came	same	shame	tame	game
12.	mad	mat	math	man	mass	37.	then	pen	den	hen	ten
13.	beige	base	bays	bathe	bayed	38.	win	fin	pin	tin	sin
14.	pack	pass	path	pad	pat	39.	shin	gin	thin	tin	chin
15.	peace	peat	peak	peas	peal	40.	thee	zee	knee	lee	dee
16.	pip	pig	pitch	pit	pick	41.	dent	went	tent	rent	bent
17.	puff	puck	pus	pup	pub	42.	dip	rip	tip	hip	lip
18.	half	hash	has	hath	have	43.	hop	pop	shop	top	cop
19.	weave	we're	wean	weed	weal	44.	gore	roar	yore	wore	lore
20.	sag	sack	sap	sad	sat	45.	thigh	high	vie	fie	thy
21.	sheave	sheen	sheath	sheaf	sheathe	46.	gyp	nip	zip	lip	slip
22.	sin	sip	sing	sit	sick	47.	nest	vest	west	rest	best
23.	sum	sun	sud	sub	sung	48.	bust	dust	rust	just	gust
24.	tab	tam	tap	tan	tang	49.	vat	fat	that	rat	mat
25.	teethe	teel	teeth	tear	tease	50.	they	gay	way	may	nay

APPENDIX B

COMMUNICATOR EVALUATION FORM

System Used:

Date:

Depth:

Total Time of Dive:

Pre-Dive:

Donning _____Easy _____Slight Difficulty _____Difficult

Check _____Good _____Marginal _____Poor

Remarks: _____

_____

During Dive:

In Water Check _____Good _____Marginal _____Poor

Intelligibility _____Good _____Marginal _____Poor

Comfort _____Good _____Marginal _____Poor

Distance Between Divers:

Remarks: _____

_____

Post-Dive

Doffing _____Easy _____Slight Difficulty _____Difficult

Remarks: _____

_____

Maintenance:

a. Directions: _____Adequate _____Inadequate

b. Procedures: _____Simple _____Complex

c. Tools Req: _____No _____Few _____Many or Special

Remarks: _____

_____

Diver-Subject's Personal Opinion:

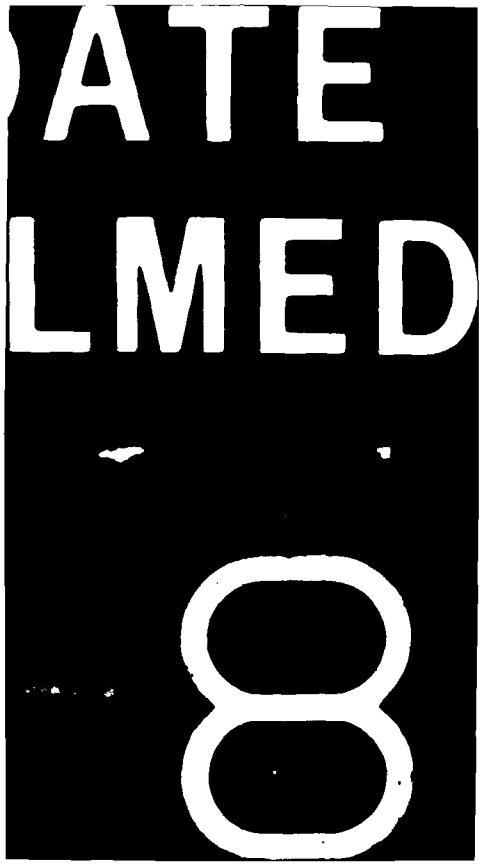
_____

_____

_____

_____

_____
Signature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